Real Time Grid Reliability Management

Reliability and Markets

November 29, 2001
Washington, DC

Robert J. Thomas

Cornell University

Power Systems Engineering Research Center

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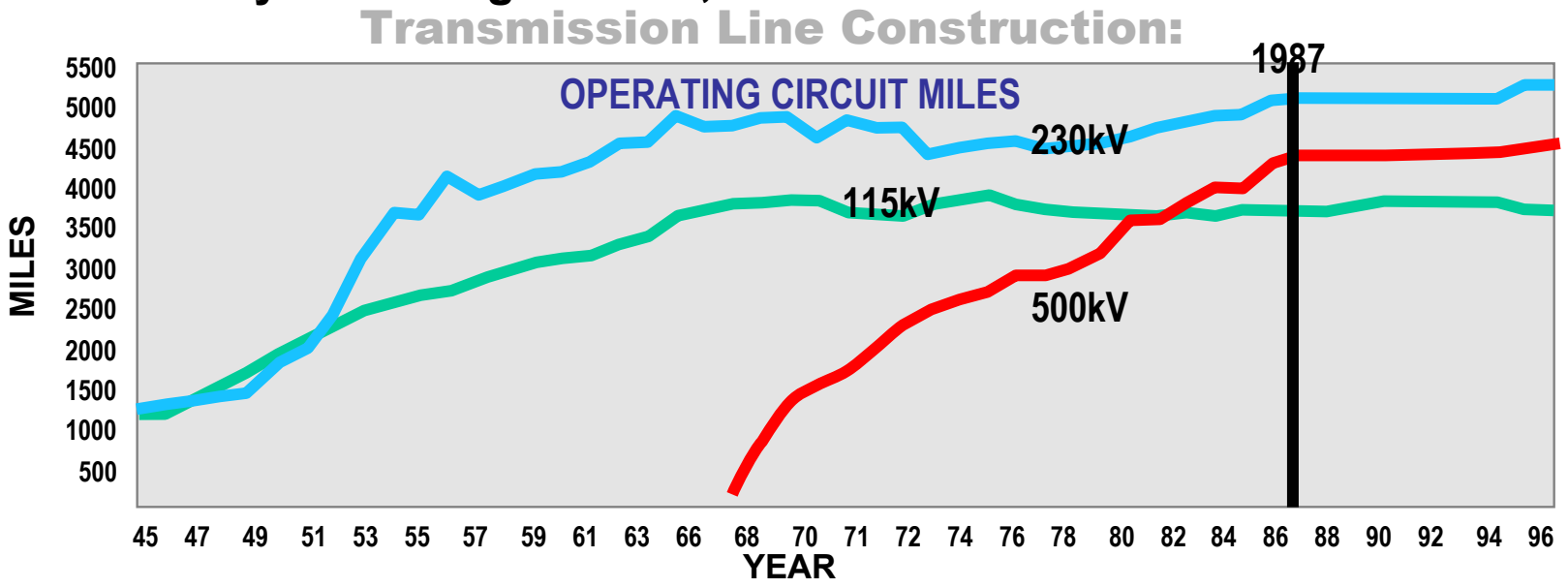
Grid Reliability Management Challenges

- Large volumes of transactions/low reserve margins stressing grid operations
- System constraints affecting use and care of the grid system
- Deregulation uncertainty contributed to reduced systems expansions and upgrades
- Western system margin is low; exact amount unknown



- Data from BPA / May 2001

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Vision For Reliability Management in Restructured Electricity Markets

- Reliability management must move from modeling machines and engineering analysis to understanding market behavior and its impact on grid systems
- Operators need real-time information that facilitates reliability management
- Operators need tools to measure, monitor, assess, and predict both system performance and the performance of market participants
- Grid needs to be enhanced to incorporate the latest advances in sensing, communication, computing, visualization, and algorithmic techniques and technologies

CERTS Real-Time Grid Reliability Management Roadmap

Reliability Adequacy and Performance

Development, and Demonstrate Reliability Adequacy Tools:

- VAR Management
- Ancillary Svcs Performance
- Wide Control Areas ACE/AIE Performance
- Effective Information Visualization

1999-2001

System Security Management Tools

Security and Congestion Assessment Tools:

- Integrated Security Analysis
- Congestion Management
- Cascading and Self Organized Criticality Utilization

2001-2003

Phasor Applications for Dispatchers and Engineers, and Future Controls

Dispatcher and Operating Engineering Applications Using Synchronized Phasor Measurements:

- Monitoring & Post Disturbance Tool
- Enhance Stability Nomograms
- Standard, Low Cost, Reliable Phasor Technologies
- Validation of Stability Models

2000-2003

Prototype New Real Time Controls

Based on Distributed Closed Loop Feedback Controls and Synchronized Phasor Measurements

2001-2005

GOAL: AN AUTOMATIC SWITCHABLE NETWORK

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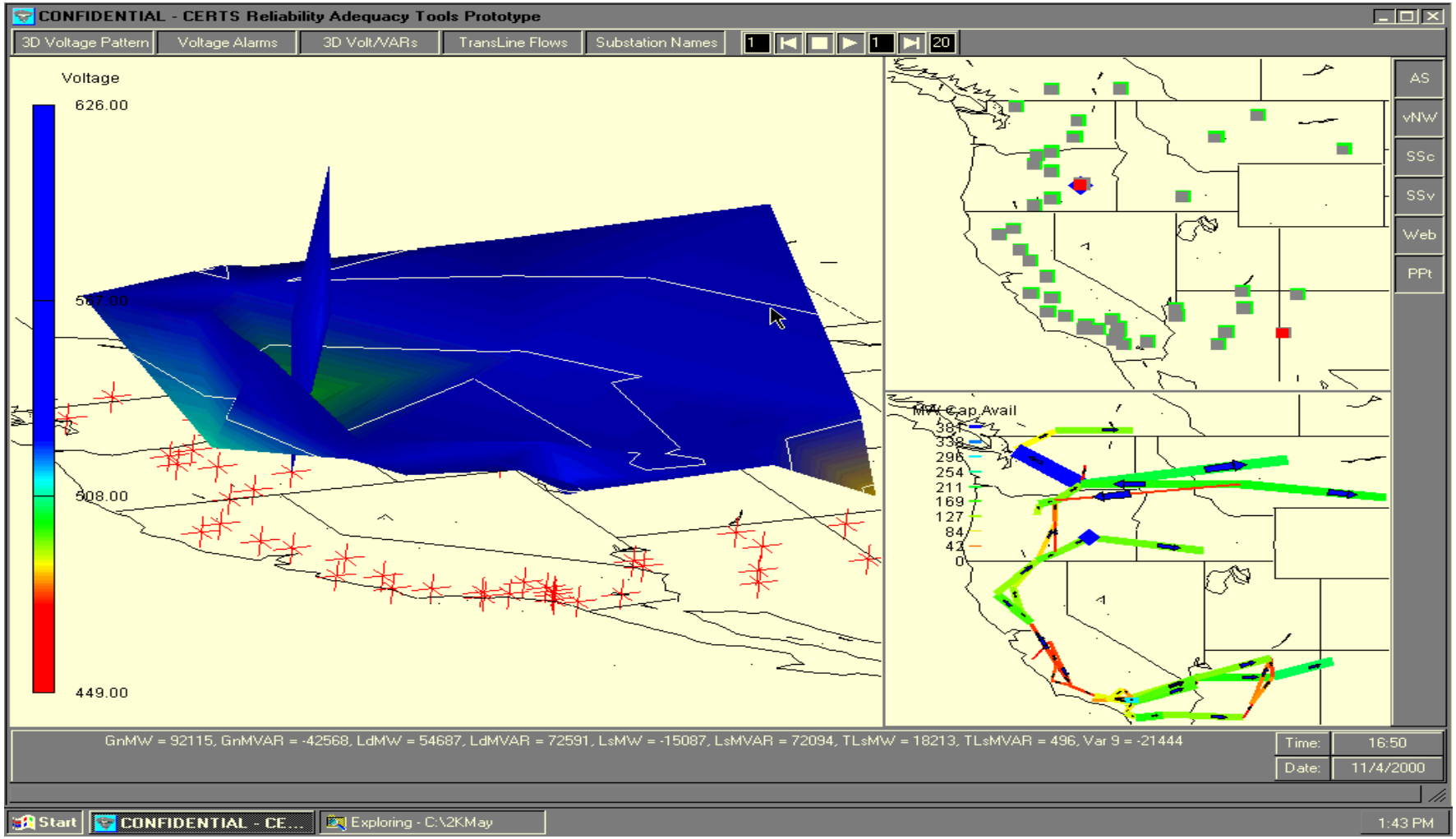
First Generation Products

- VAR Management Tool
  - Developed by DOE in FY99-FY00
  - CEC funding to demonstrate at CAISO - Fall 2001
  - In discussion with AEP for future demonstration
- NERC ACE/AIE Compliance Monitoring Tools
  - Developed by DOE in FY01
  - Demonstrations at NERC Security Coordinators – Fall 2001
- Synchronized Phasor Measurement Workstation
  - Developed by DOE/EPRI/BPA/WAPA in WAMS program
  - CEC funding to demonstrate updated workstation at CAISO - Fall 2001
  - In discussions with AEP and TVA for future demonstrations

CERTS VAR Management Tool: Turns Data Into Information



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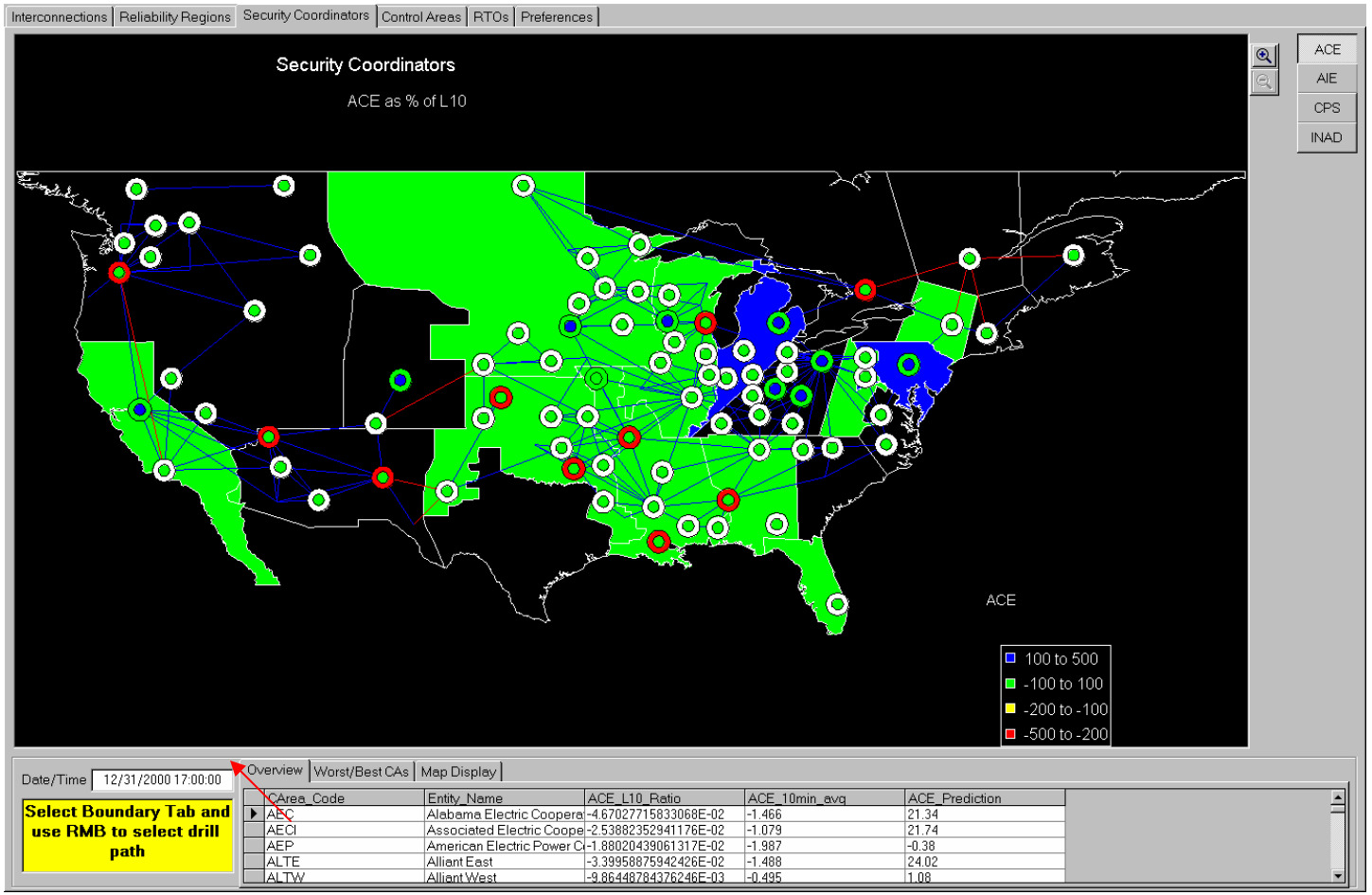
Capability could have prevented 1996 WSCC Outage

ACE Monitoring – Identifies Problems In Real-Time and Supports Corrective Action



Global
Local
Tracking

Each bubble represents a Control Area. The Inner most color is the ACE. The outermost is the ratio ACE/L10 where ACE / L10 > 1 Red, ACE / L10 < 1 Blue, and anything else = White.

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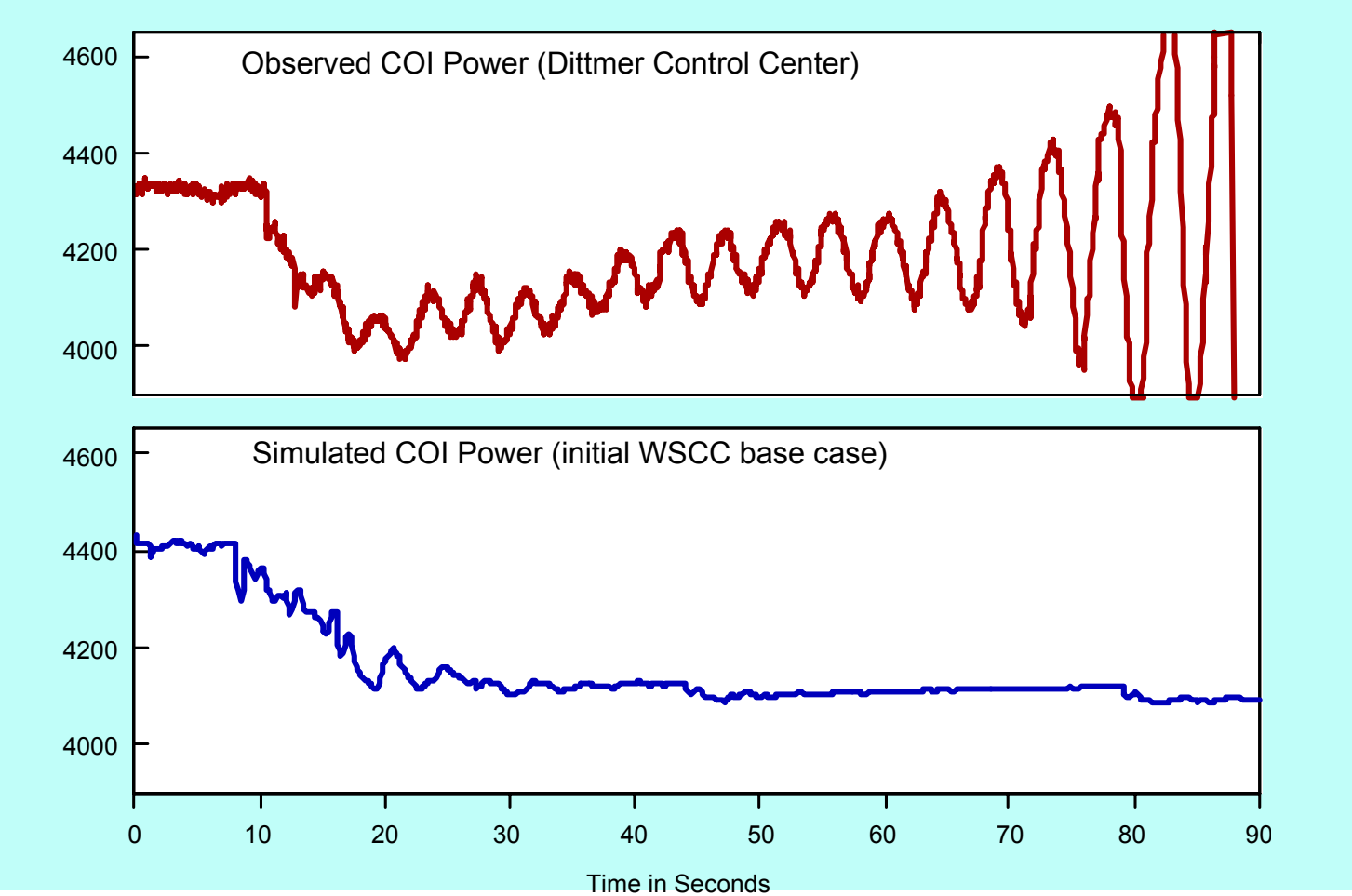
Modeling failure for WSCC breakup of August 10, 1996

(MW on California-Oregon Interconnection)



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Reliability and Markets – What are we working on?

- Understanding linkages between the physical grid and market mechanisms that will lead to the development of a new generation of design and operating tools

- Tools to increase reliance on market forces to ensure system reliability

- Market designs for system reliability needs (stable and efficient) validated through experimental testing

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Why do experimental testing of electricity markets?

- There is a large gap between observed behavior and what is predicted by economic theory
- Currently known models are too complex for theory to adequately address a complete analysis
- Less expensive financially and socially to try new concepts in the lab before trying them on a state

Objectives

Replicate the high price volatility observed in existing electricity markets using a "smart" market (POWERWEB)

- 30 Bus Network
- Human subjects (6) represent generators
- Pay real money proportional to profits
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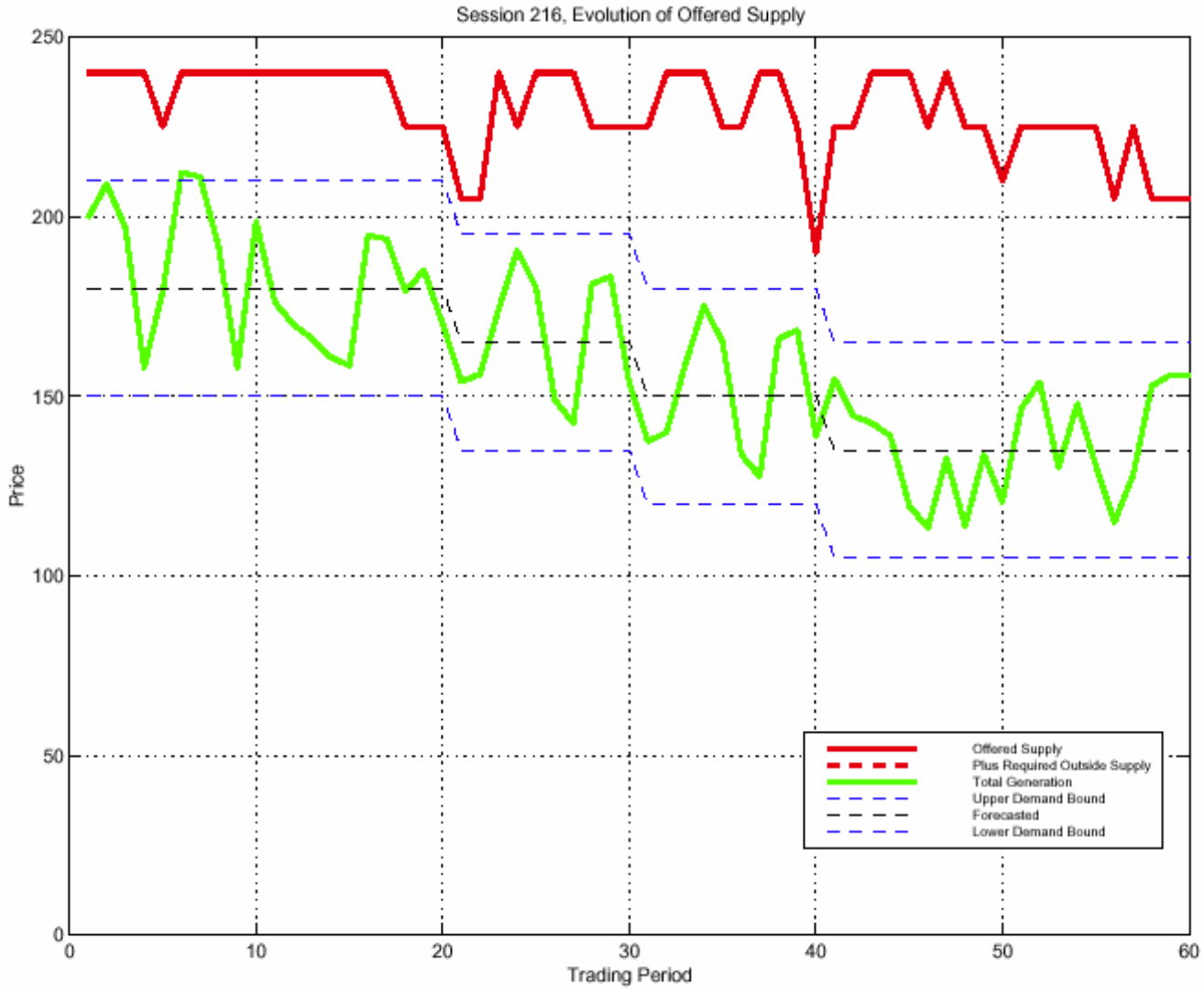
- Pay real money proportional to profits
- Use various auction mechanisms
- Make load stochastic
- Standby charges for participation

Test four different auctions

- Uniform price auction with price inelastic load (last accepted offer)
- Uniform price auction with price responsive load
- Discriminative auction (pay actual offers)
- Soft cap auction (uniform price below and discriminative price above)

Capacity Offered into an Auction Without Standby Costs



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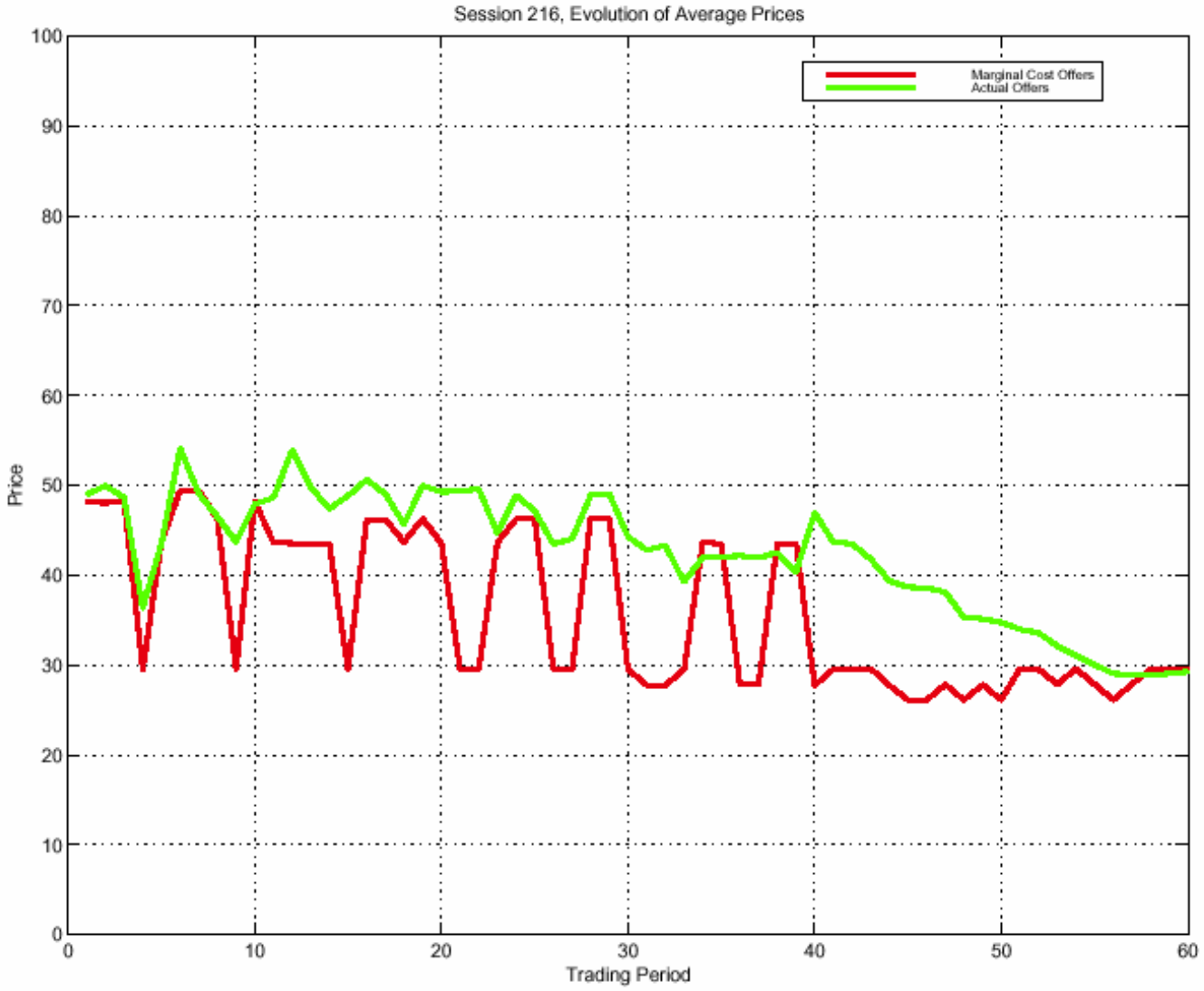
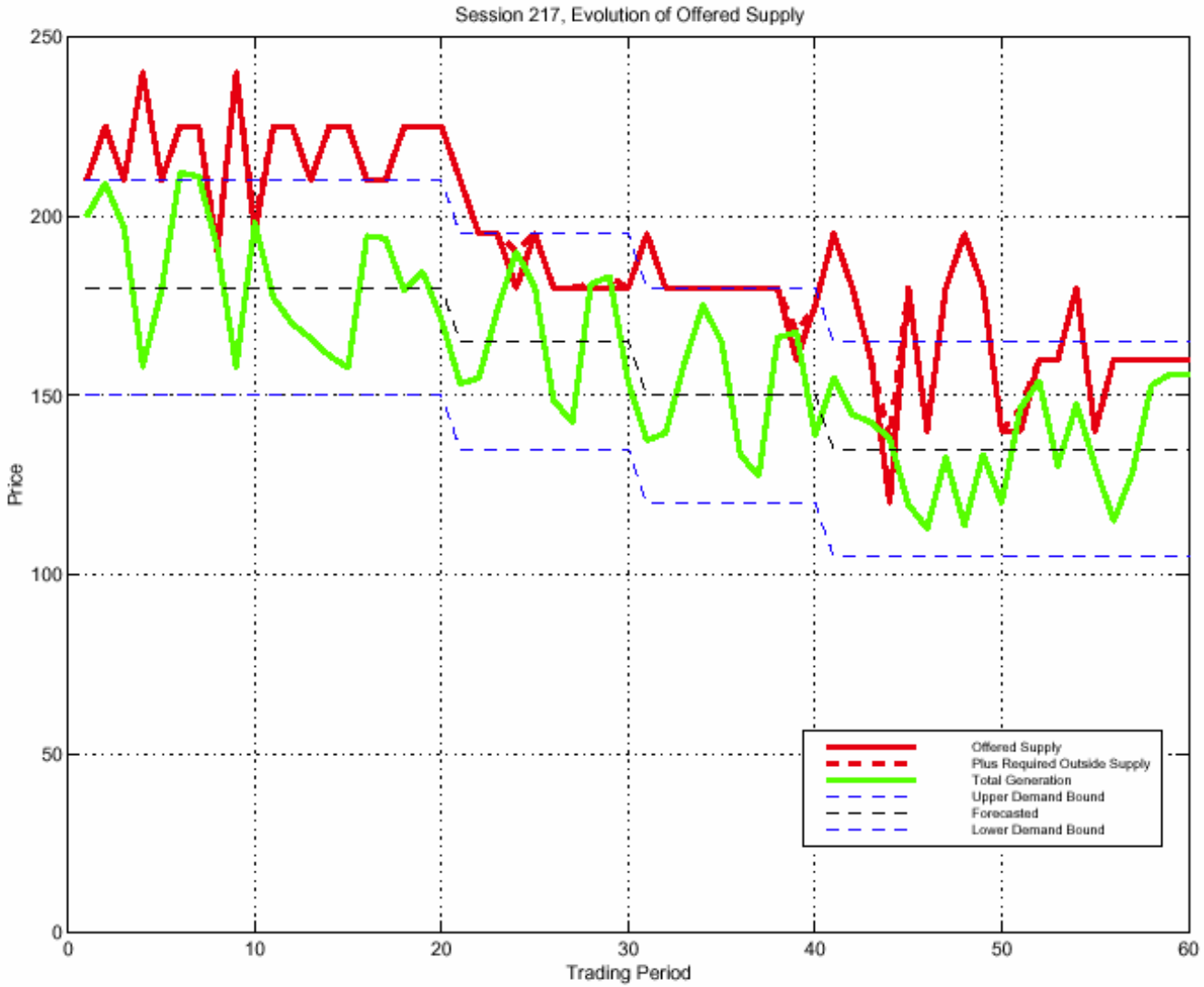
Market Prices Without Standby Costs



Capacity Offered into an Auction with Standby Costs



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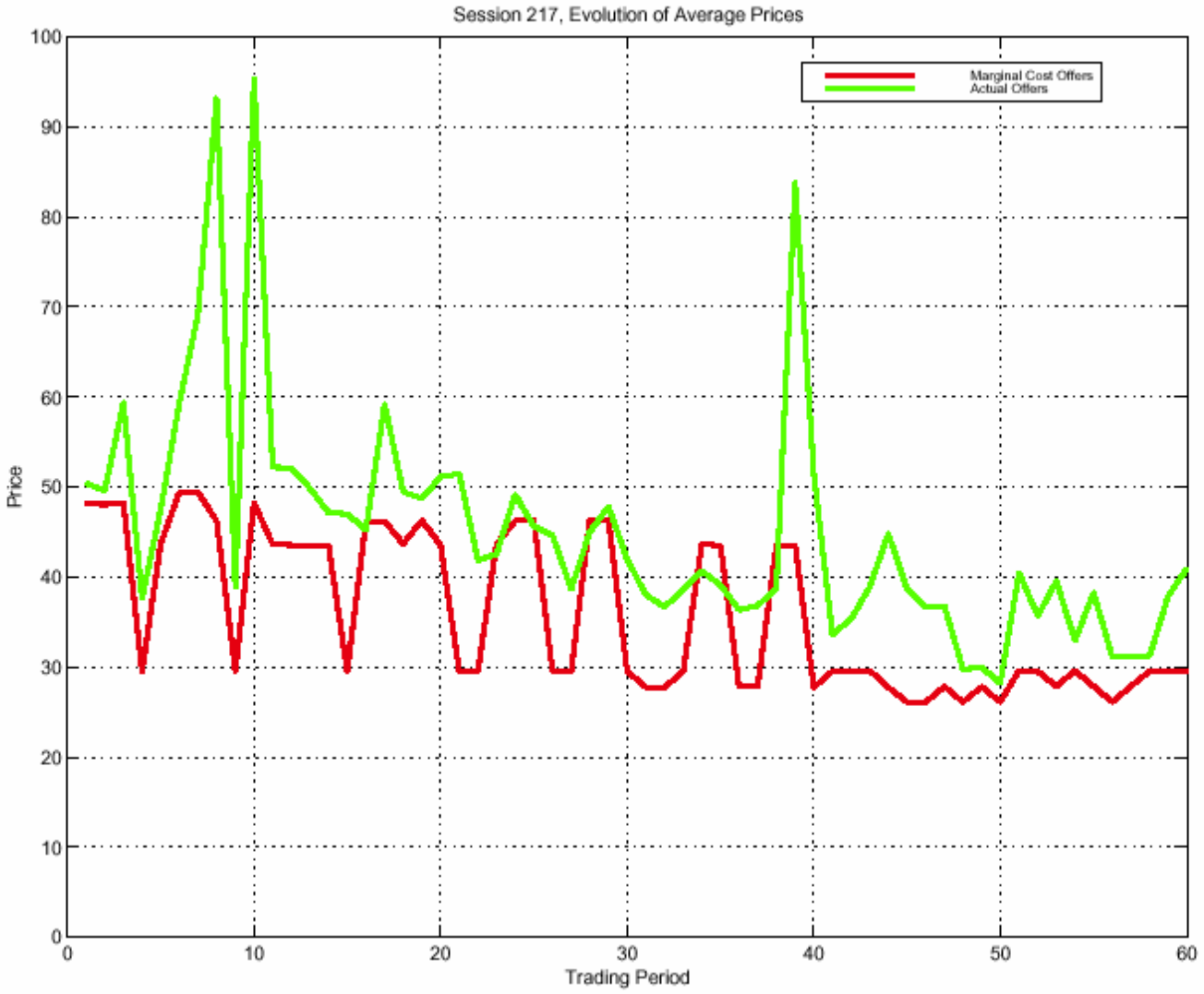
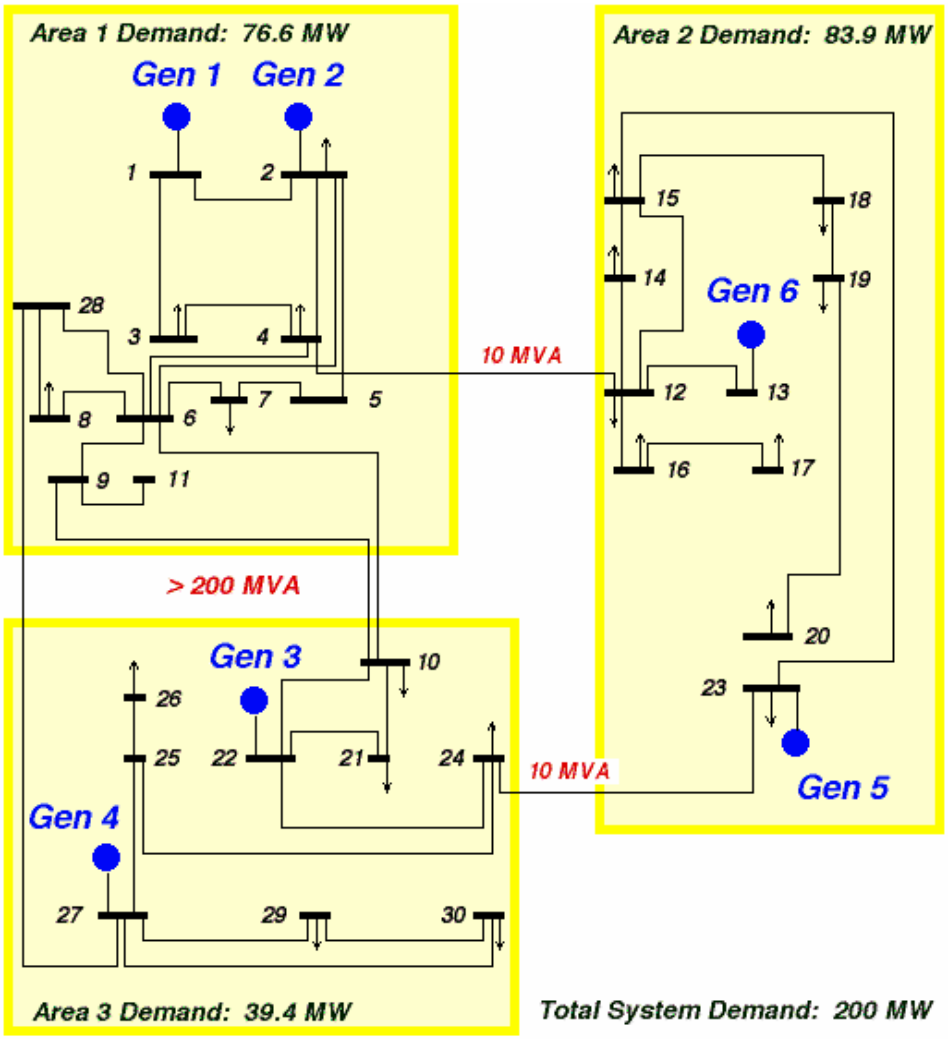
Market Prices with Standby Costs



PowerWeb



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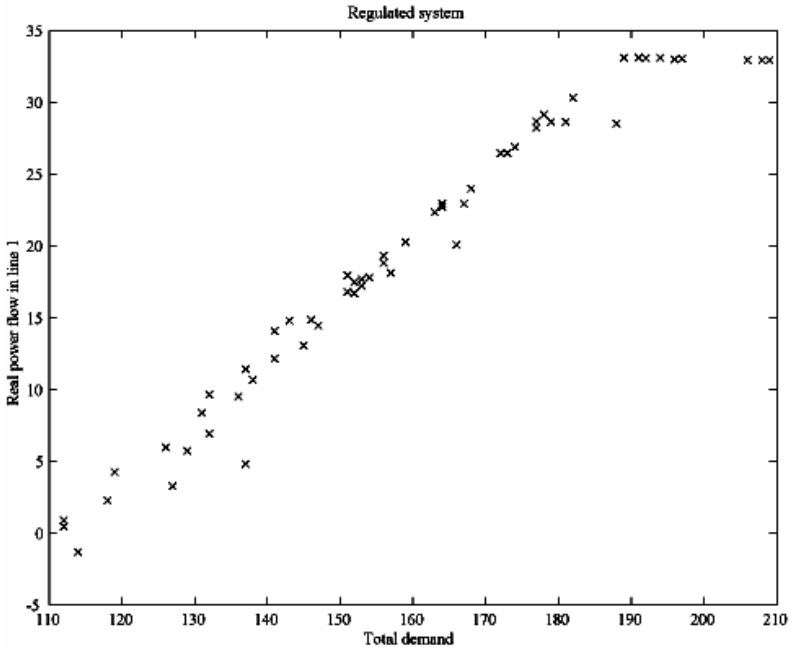
Can Operators Predict Market Behavior?

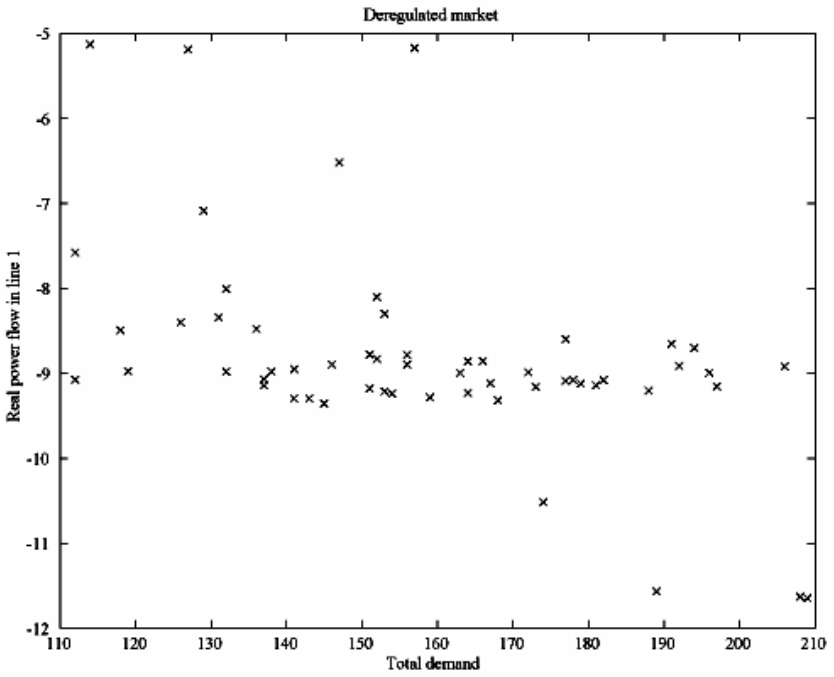
Results of Market Simulations Performed by PSERC

Regulated System



- Economic dispatch
- Strong correlation between power flow and demand

Deregulated Market



- Market-based dispatch
- Poor correlation between power flow and demand

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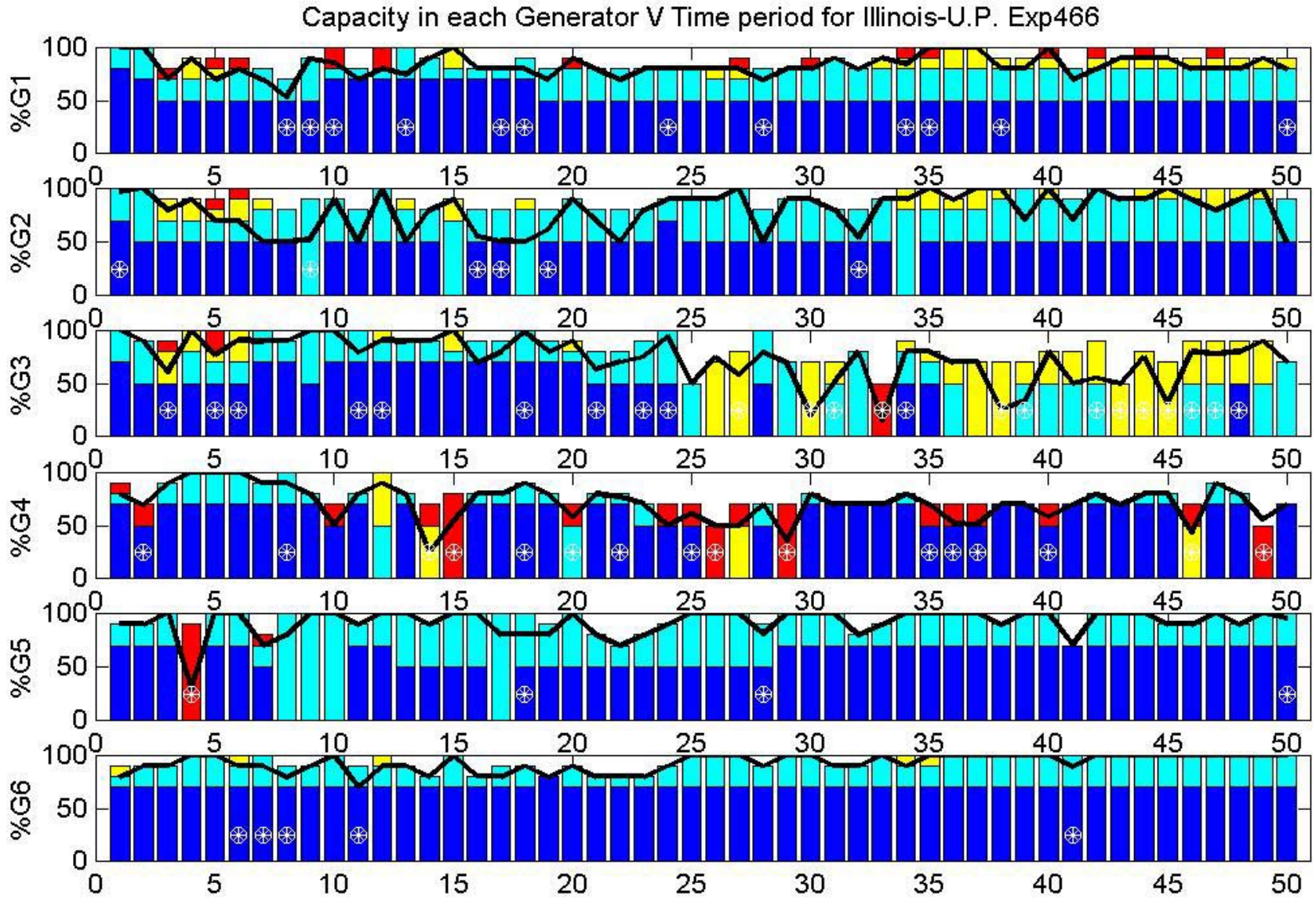
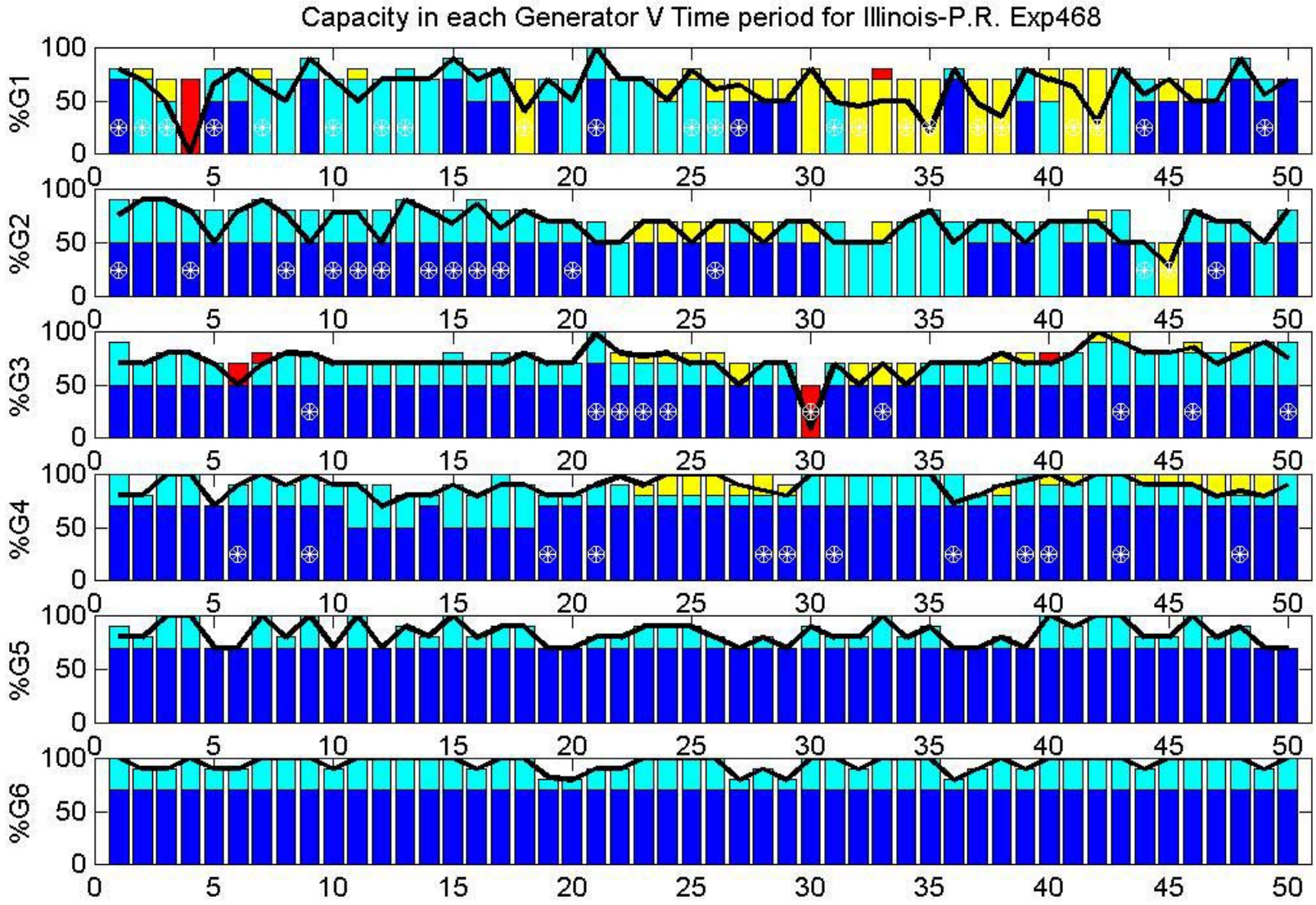


dark blue <$50/MWh - light blue $50-$75/MWh - yellow $75-$90/MWh - red >$90/MWh



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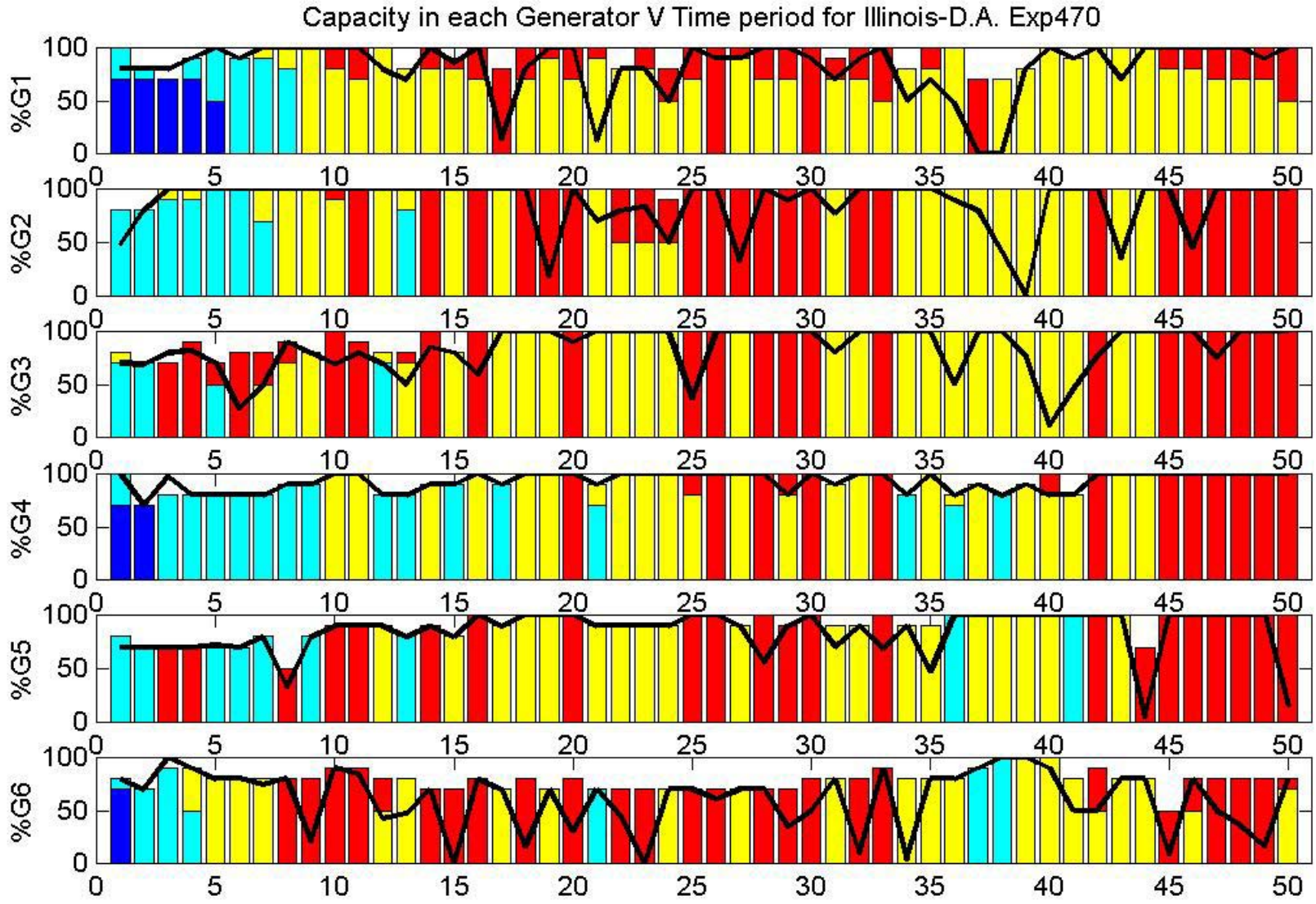

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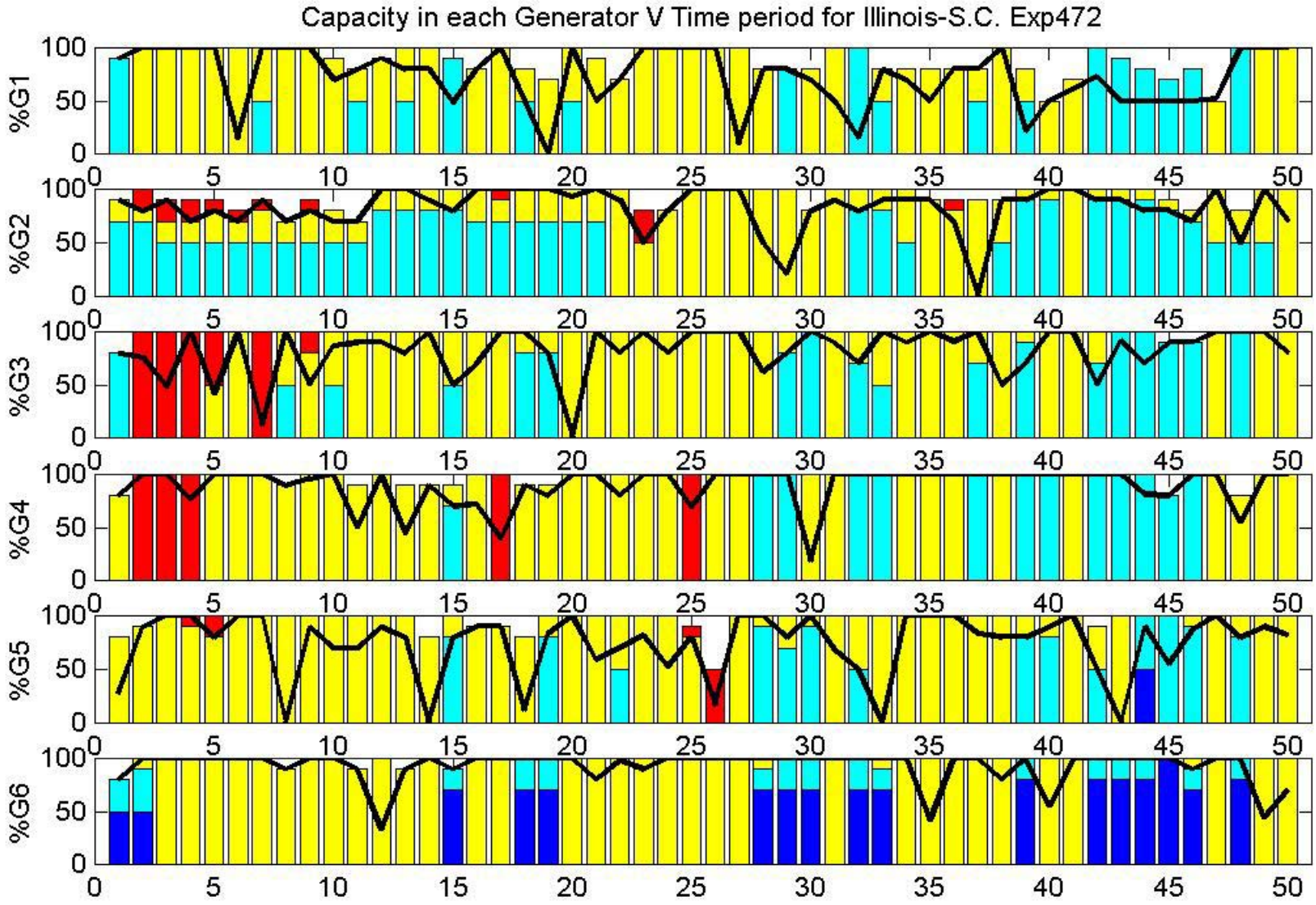

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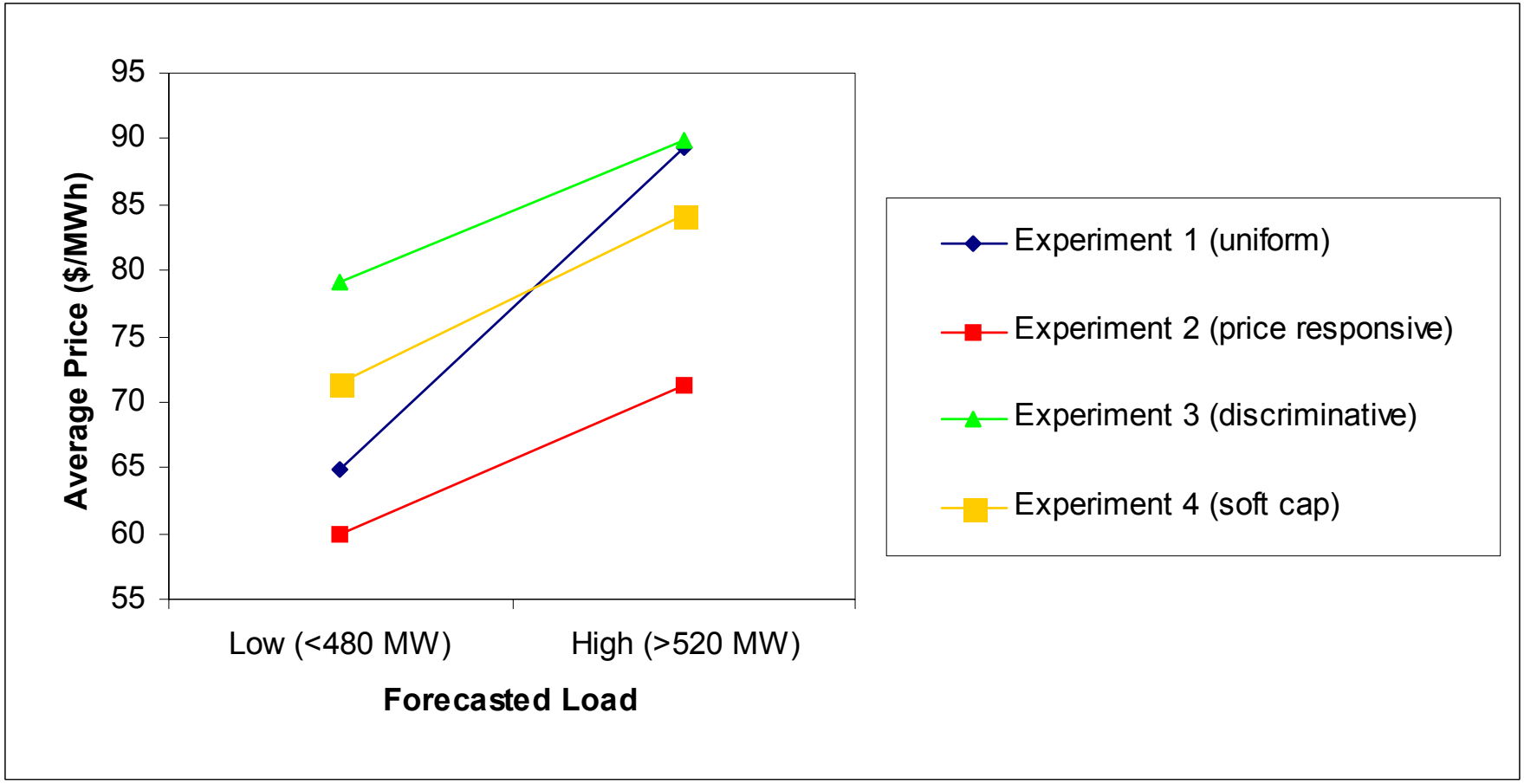
Average Prices for High and Low Loads



What have we tested for?

- Simple energy auctions
  - cost efficiency
  - competitive pricing
  - price spikes
  - market power
  - unit-commitment issues
  - pay-as-bid/soft-cap auctions
- Multi-dimensional auctions
  - reactive power
  - reserves
  - regulation, load following, etc.